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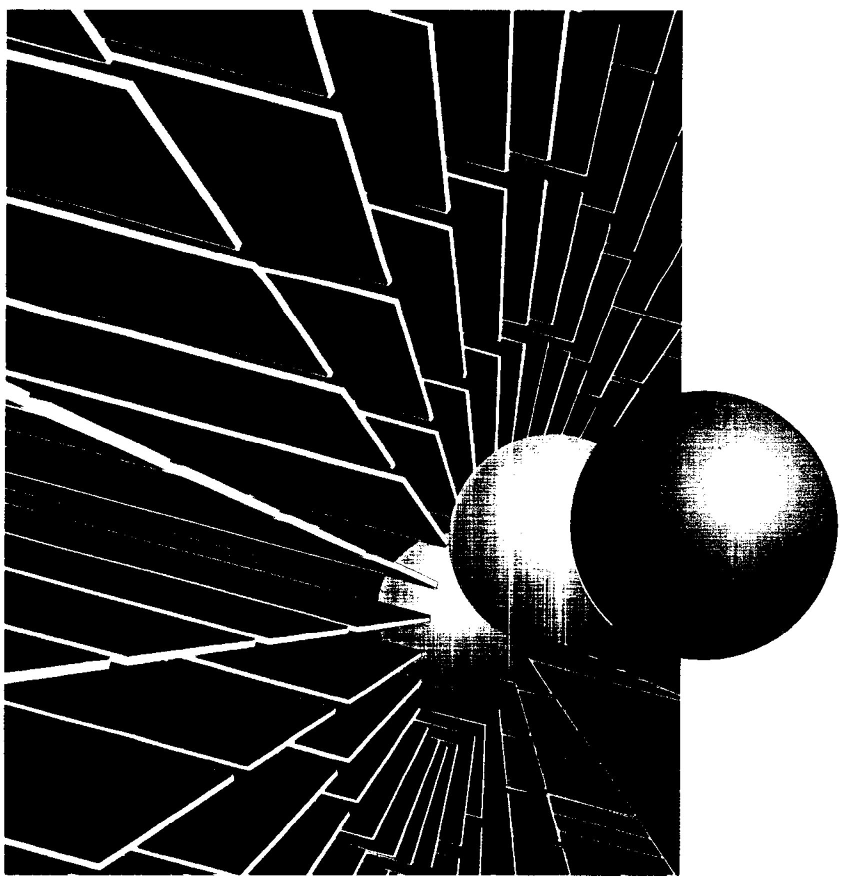
Research, Development and Technology

RDT 02-01

Water Reducing Admixtures in Portland Cement Concrete Pavement (PCCP) on Route 60, Carter County

RI 00-001(B)



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15. Supplementary Notes
The investigation was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration.

16. Abstract
The purpose of this investigation was to verify and supplement the findings of research investigation RI00-001A, "Water Reducing Admixtures in PCCP Mixes", Report No. RDT 01-004. The objective of RI00-001 is to determine the potential benefits and cost savings of adding a Type A water reducer and lowering the cement content in MoDOT's PCCP mixes.

This research report presents the testing results from a second field study conducted on Route 60 in Carter County (J9P0282) in which a PCCP mix containing a Type A water reducer with a ¼-sack reduction in cement was compared to MoDOT's conventional PCCP mix. The concrete specimens fabricated in the field were tested to determine the following characteristics of the PCCP mixes:

7-day compressive strength	(AASHTO T22)
28-day compressive strength	(AASHTO T22)
7-day flexural strength	(AASHTO T97 or T177)
28-day flexural strength	(AASHTO T97 or T177)
freeze-thaw durability	(AASHTO T161)
air void analysis	(ASTM C457)
rapid chloride permeability	(AASHTO T277)

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RESEARCH INVESTIGATION RI00-001B

FIELD STUDY
WATER REDUCING ADMIXTURES
IN PCCP ON RT 60, CARTER COUNTY

PREPARED BY
MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT, AND TECHNOLOGY

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Eric Burks, Larry Diaz, Chris Graham, and Dave Amos, RD&T technicians, conducted field sampling and fabricating concrete specimens for this project.

Steve Jackson, Physical Testing Supervisor, scheduled and tested all concrete specimens fabricated in this project and reported the results in a timely manner.

The author is also grateful to John Donahue for manuscript review.

EXECUTIVE SUMMARY

This study was conducted to verify and supplement the findings of research investigation RI00-001A, "*Water Reducing Admixtures in PCCP Mixes*", *Report No. RDT 01-004*. The objective of RI00-001 is to determine the potential benefits and cost savings of adding a Type A water reducer and lowering the cement content in MoDOT's PCCP mixes. The previous field study indicated poor freeze/thaw performance by both the control and water reducer (WR) mixes, which was thought to be the characteristics of the aggregate source. Also, the control mix had approximately 12% higher freeze/thaw durability compared to the WR mix. The results from the previous study initiated this field study to verify the performance characteristics of the WR mix, especially the freeze/thaw durability.

This report presents the testing results from the second field study conducted on Route 60 in Carter County (J9P0282) in which a PCCP mix containing a Type A water reducer with a ¼-sack reduction in cement content was compared to MoDOT's conventional PCCP mix. The main findings of this study are summarized as follows:

- Both the control and the WR mixes had a freeze/thaw durability of 82%. The water reducer shows no additional benefit or detriment to the freeze/thaw durability of concrete in this study.
- The air void systems for the control and water reducer mixes were satisfactory for good freeze/thaw resistance.
- The WR mix significantly reduced chloride permeability compared to the control mix.
- The WR mix was significantly higher in compressive and flexural strengths compared to the control mix.
- The PCCP mix containing the water reducer with a ¼-sack reduction in cement cost less than a standard PCCP mix. The proposed savings for this study was approximately $0.59 per cubic yard.

Based upon the previous laboratory and field study and the results obtained in this investigation, Research, Development, and Technology conclude that Type A water reducers with a ¼-sack reduction in cement can be used to obtain better concrete characteristics at lower costs compared to conventional PCCP mixes. Research, Development, and Technology recommend that revisions be made to allow Type A water reducer with ¼-sack cement reductions in MoDOT PCCP mix designs. Further investigation of Type A water reducers and pozzolans (i.e. slag, flyash, silica fume) are currently underway in the laboratory and final conclusions should be available in 2003.

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OBJECTIVE

The objective of this project is to verify and supplement the findings of research investigation RI00-001(A), "Water Reducing Admixtures in PCCP Mixes." The objective of RI00-001 is to determine the potential benefits and cost savings of adding a Type A water reducer and lowering the cement content in MoDOT's PCCP mixes.

Concrete specimens were fabricated from a project on Rt. 60 in Carter Co. and were tested to determine the following fresh and hardened characteristics of the PCCP mixes:

w/c ratio	
slump	(AASHTO T119)
air content	(AASHTO T152)
freeze-thaw durability	(AASHTO T161)
air void analysis	(ASTM C457)
rapid chloride permeability	(AASHTO T277)
7-day compressive strength	(AASHTO T22)
28-day compressive strength	(AASHTO T22)
7-day flexural strength	(AASHTO T97 or T177)
28-day flexural strength	(AASHTO T97 or T177)

TECHNICAL APPROACH

Concrete field-testing was conducted on a PCCP project on Route 60 in Carter County (J9P0282). PCCP mixes containing a Type A water reducer with ¼-sack cement reduction ("WR mixes") were compared to MoDOT's standard PCCP mixes without water reducer and cement reductions ("control mixes") to determine the potential benefits and cost savings of a Type A water reducer.

Concrete specimens were fabricated from the control and WR mixes and laboratory tested for freeze thaw durability, air void structure, chloride permeability, and compressive and flexural strengths, following the appropriate AASHTO and ASTM Standard Specifications as listed above. The fabrication of concrete test specimens was conducted according to AASHTO T23, *Making and Curing Concrete Test Specimens in the Field.*

For a thorough comparison of water reducer mixes versus the control mixes, the contractor was requested to follow a certain paving sequence. The paving sequence started with a control mix, then switched to the WR mix, and finally returned back to the control mix, all within the same day. Sampling and fabricating of the concrete test specimens were performed at four intervals within this sequence. Figure 1 illustrates the order of the paving sequence. Sampling of concrete was conducted at the batch plant where a representative sample was obtained for each sampling interval. Each test interval within the paving sequence represents approximately 130 cubic yards of concrete in which sampling and fabrication of test specimens were conducted. Specimens fabricated from Control Interval 1 (CI-1) represented the sampling of the first control mix. The

Water Reducer Intervals 1 and 2 (WRI-1&2) represented the water reducer mix with a ¼ - sack reduction in cement per cubic yard. CI-2 completed the sampling for the control mix. The same paving sequence of four intervals was then repeated a second day during which concrete specimens were fabricated and tested from CI-3, followed by WRI-3 & 4, and finally CI-4.

Prior to the actual paving, the contractor was required to submit the proposed mix designs which included material sources and the water cement ratios, provide an outline of the proposed savings comparing the cost of the additional admixture to the savings in cement, and provide specific construction details to insure uniformity in materials, mix designs, and placement procedures.

The source/manufacturer and description of the materials that were used for the field study are as follows:

Coarse Aggregate:	Gasconade Dolomite, Williamsville Stone #4 Gradation B
Fine Aggregate:	Crowley Ridge Class A Brown's Sand and Gravel Dexter, MO
Cement:	LoneStar Cape Girardeau Plant Type 1
Air Agent:	General Resource Technology (GRT) Polychem VR Air Entraining Admixture
Water Reducer:	General Resource Technology (GRT) (Used in WR mixes only) Polychem 400NC Type A Water Reducer

RESULTS AND DISCUSSION

Concrete Characteristics

The results from field testing of the water reducer mixes and control mixes for freeze thaw durability, air void structure, chloride permeability, and compressive and flexural strengths of each study are described within the following sections. Fresh concrete characteristics (slump, air, w/c ratio) are listed in the Table 1. Control Interval 1 (CI-1) had only 1.5 % air content, which is well below the Missouri Standard Specifications for Highway Construction[1] (4 - 7 %). Therefore, the results from this interval are not included in the analysis. Water Reducer Interval 1 (WRI-1) contained 8 % air content, which also did not meet air entrainment requirements by specification. However, the results were considered reasonable to include in the final analysis.

Freeze/Thaw Durability (AASHTO T161)
Concrete beams were fabricated on the Rt. 60 project and tested according to AASHTO T161, *Resistance of Concrete to Rapid Freezing and Thawing*. Six or eight beam specimens were fabricated from each interval and tested in 300 freeze/thaw cycles. The freeze/thaw durability were calculated and averaged for each interval and are listed in Table 2. Freeze/Thaw durability for individual test specimens can be found in Appendix A.

The freeze/thaw (F/T) durability of both the control mix and the water reducer mix averaged 82%. The F/T testing results indicate that the water reducer had no benefit or detriment to the freeze/thaw durability of concrete in this study.

The F/T results from CI-1 were not included in this study. The mix from CI-1 contained only 1.5% air content, which does not meet MoDOT specifications and is not acceptable for good freeze/thaw performance. The average F/T durability of CI-1 was 44%.

WRI-1 exceeded MoDOT specification for air content by 1%. The increased air content did not affect the freeze/thaw durability. The average F/T durability of WRI-1 was 82%. Two specimens from WRI-3 were discarded and not included in the average. The two specimens were significantly lower than the other six specimens within the same interval. The reason for this difference is unclear, but may be due to segregation or poor consolidation of the test specimens.

Air Void Analysis
Eight specimens (one from each interval) were fabricated at the Rt. 60 project in which the air void structures were analyzed and compared. The laboratory worksheets are included in Appendix B. The water reducer in this field study did not significantly affect the air void structure compared to the control mix. However, the WR mix appeared to have slightly larger sized air bubbles that were spaced further apart compared to the control mix. The WR mix met all American Concrete Institute (ACI) recommended air void parameters. The control mix's specific surface was slightly higher than what is recommended by ACI. It appears that both the WR and control mixes had acceptable air void structure for good freeze/thaw durability as was indicated by the F/T results.

Rapid Chloride Permeability (AASHTO T 277)
The WR mixes in this study had significantly lower chloride permeability compared to the control mix. The average permeability (Coulombs) of the WR mix and the control mix are listed in Table 3.

Generally, permeability greater than 4000 C is considered high. Moderate permeability is considered between the ranges 2000 – 4000 C. The water reducer appeared to decrease the permeability of a standard mix from a high permeability range to the moderate range.

Compressive Strength (AASHTO T22) and Flexural Strength (AASHTO T97)
Compressive and flexural strength data were collected from 7 and 28-day concrete cylinders and beams taken from both the control mix and the water reducer mix. The average 7 and 28-day strengths for both mixes are listed in Table 4. Figures 2 and 3 graphically show each water reducer interval compared to the control for compressive and flexural strengths, respectively. Appendix D contains strength results for individual specimens taken from each interval and other mix characteristics. Both the water reducer mix and the control mix had similar water/cement ratios (approximately 0.45).

The strength results from CI-1 were not included in this study. The mix from CI-1 contained only 1.5 % air content. This caused higher than normal strengths and would only skew the average results.

WRI-1 exceeded MoDOT specification for air content by 1%. Although it did not meet MoDOT specifications, it was included into calculating the average. This was the only water-reducing interval that had lower strengths compared to the control mixes due to the 1% higher air content. The higher air content will lead to lower compressive strengths for the interval. Generally for every 1% increase in air content, there is approximately a 10 % reduction in compressive strength[2].

Effects to Air Entrainment Dosage
Like the previous study has indicated, the air entrainment dosage in this study decreased by over 60%. The control mix required approximately 8 to 9 oz./yd^3 and the WR mix required about 3 oz./yd^3. Air entrainment dosages vary somewhat in the field and are generally caused by changes in air temperature. However, the addition of water reducer will decrease the amount of air entrainment dosage needed in the mix.

Effects to Water/Cement Ratio
The water/cement (w/c) ratio at the batch plant varied somewhat from the initial mix design. It was also difficult to obtain the exact batch plant sheet in which specimens were taken in this study. Several batch sheets were obtained from approximately the same time frame as when the specimens were fabricated, and an average w/c ratio was calculated. The average water/cement ratios of the control mix and the WR mix for the two testing dates are listed in Table 5. The w/c ratio of the WR mix and control mix were approximately 0.45.

A minimum of a 5% water reduction is a general requirement of AASHTO M 194 for a Type A water reducer. Typical Type A water reducers reduce the water content by approximately 5% to10%[3]. The reduction in cement in the WR mix causes a decrease in workability that counteracts the effect of the water reducer when achieving a target slump. Therefore, the water reducer may not change the water/cement ratio when the cement content is decreased. This has also been verified in the previous studies.

CONCLUSIONS

This report presents results from a second field study conducted on Route 60 in Carter County (J9P0282) in which a PCCP mix containing a Type A water reducer with a ¼-sack reduction in cement content was compared to MoDOT's conventional PCCP mix. The main findings of this study are summarized as follows:

- Both the control and the WR mixes had a freeze/thaw durability of 82%. The water reducer shows no additional benefit or detriment to the freeze/thaw durability of concrete in this study.
- The air void systems for the control and water reducer mixes were satisfactory for good freeze/thaw resistance.
- The WR mix significantly reduced chloride permeability compared to the control mix. This was also indicated in the previous study.
- The WR mix was significantly higher in compressive and flexural strengths compared to the control, which follows the trends of the previous study.
- The PCCP mix containing the water reducer with a ¼-sack reduction in cement cost less than a standard PCCP mix. The proposed savings for this study was approximately $0.59 per cubic yard.

RECOMMENDATIONS

Based upon laboratory and field testing results and observations; Research, Development, and Technology recommends the following:

- Research, Development, and Technology recommend that revisions be made to allow Type A water reducer with ¼-sack cement reductions in MoDOT PCCP mix designs.
- The minimum dosage rate of a Type A water reducer should be established by the dosage rate submitted for the initial admixture approval and within the ranges recommended by the manufacturer.
- Further evaluation of PCC mixes containing Type A water reducers, cement reductions, and pozzolan replacements is needed to improve PCC performance characteristics, produce a less expensive mix, and become more environmental friendly.

BIBLEOGRAPHY

1. 1999 Missouri Standard Specifications for Highway Construction, Section 1054.3. (References AASHTO M194)

2. Hover, K.C., *Air Content and Unit Weight of Hardened Concrete*, Significance of Tests and Properties of Concrete and Concrete-Making Materials, ASTM STP 169C, p. 297.

3. Portland Cement Association, *Design and Control of Concrete Mixtures*, Thirteenth Edition, Skokie, Illinois, 1994, p. 65 and 66.

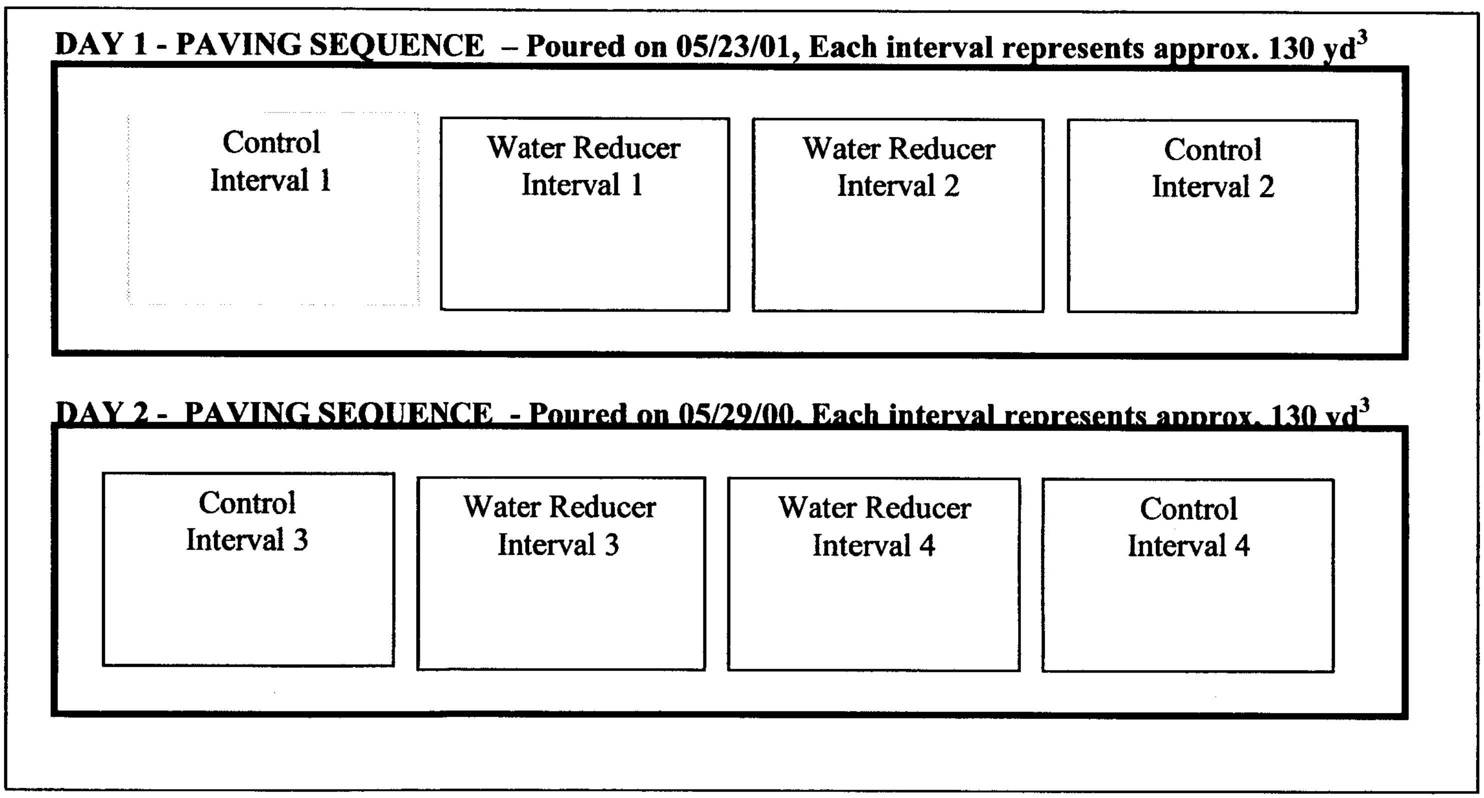


Figure 1 – Field Paving Sequence and Sampling Interval

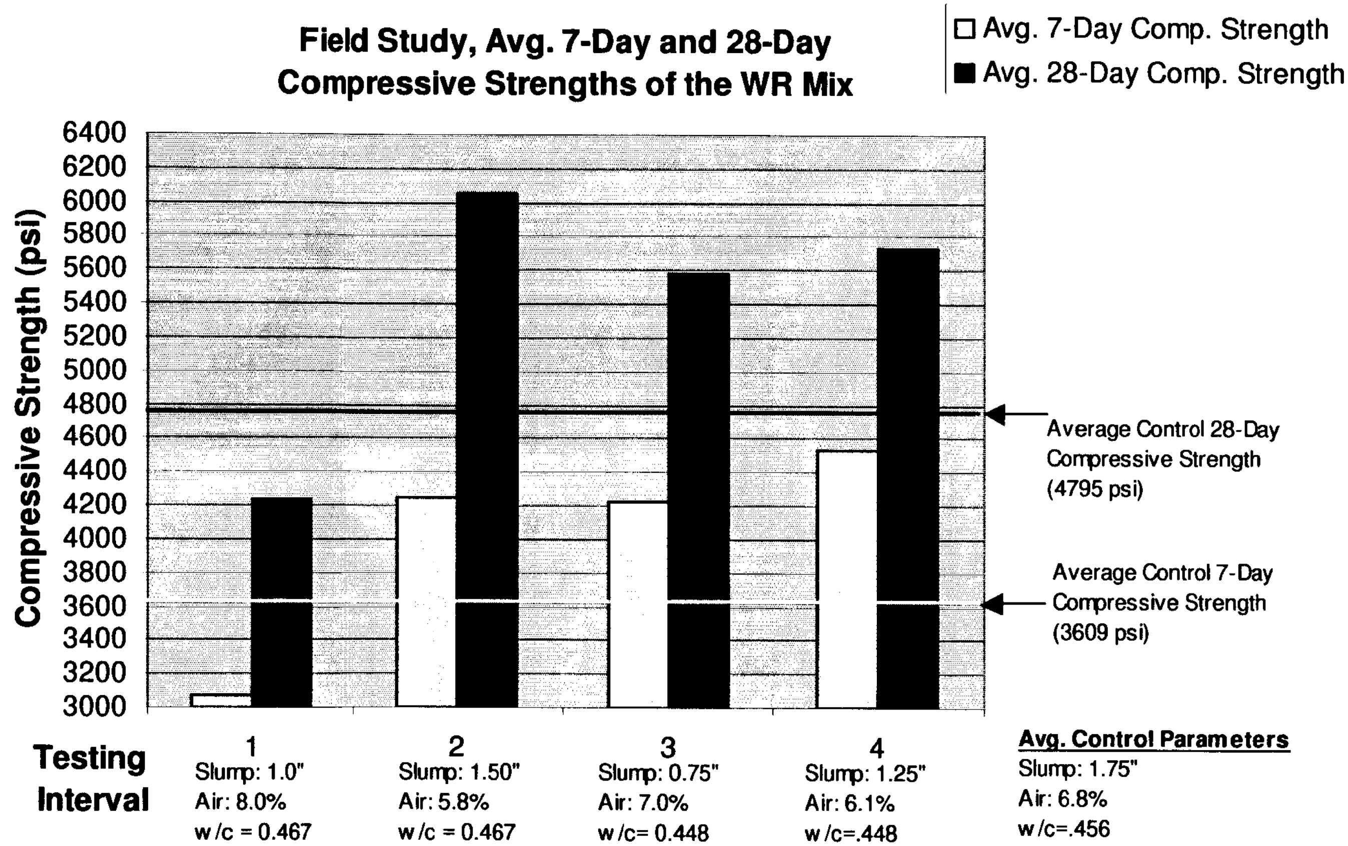


Figure 2 - Field Study, Avg. 7 and 28-Day Compressive Strengths of Water Reducer Mix Intervals

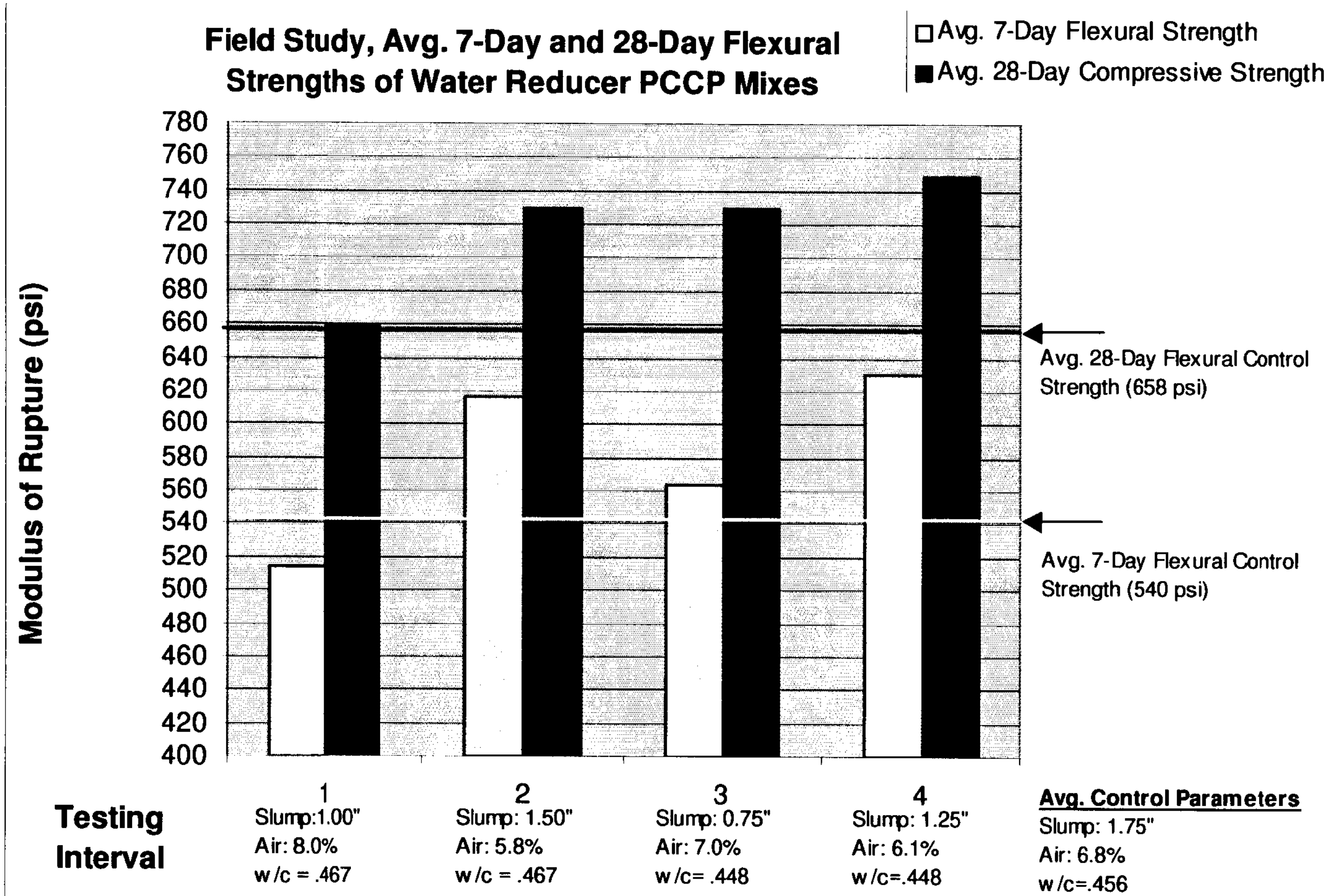


Figure 3 - Field Study, Avg. 7 and 28-Day Flexural Strengths of Water Reducer Mix Intervals

AVERAGE CONCRETE CHARACTERISTICS						
Interval No.	**Cement / Fly Ash (lb/yd^3)**	**Avg. Water Red. ($oz./ yd^3$)**	**Avg. Air Agent (oz/yd^3)**	**Avg. W/C Ratio**	**Slump (in)**	**Air (%)**
Control 1	573	0	8.0	455	1.5	1.5
Control 2	573	0	8.0	.455	1.5	6.9
Control 3	573	0	9.0	.457	1.75	6.7
Control 4	573	0	9.0	.457	2.25	6.9
AVG	**573**	**0**	**8.5**	**.456**	**1.75**	**6.8**
WR 1	546	20.0	2.5	.467	1.0	8.0
WR 2	546	20.0	2.5	.467	1.5	5.8
WR 3	546	20.0	3.0	.448	.75	7.0
WR 4	546	20.0	3.0	.448	1.25	6.1
AVG	**546**	**20.0**	**2.8**	**.458**	**1.0**	**6.7**

Table 1 – Average Concrete Characteristics

CONTROL INTERVALS	**FREEZE/THAW DURABILITY**
Control 1	(44) Not Included
Control 2	83.0
Control 3	80.3
Control 4	83.8
Average	**82.4**
WATER REDUCER INTERVALS	**FREEZE/THAW DURABILITY**
Water Reducer 1	81.6
Water Reducer 2	82.7
Water Reducer 3	80.2
Water Reducer 4	84.1
Average	**82.1**

Table 2 – Average Freeze/Thaw Durability Results

MIX TYPE	**CONTROL MIX**	**WATER REDUCER MIX**
Avg. 28-Day Permeability (C) Top Lift	4941	3481
Avg. 28-Day Permeability (C) Middle Lift	5431	3559
Avg. 56-Day Permeability (C) Bottom Lift	4044	3288

Table 3 – Average Chloride Permeability Results

MIX TYPE	CONTROL MIX	WATER REDUCER MIX
7-Day Compressive Strength (psi)	3609	4021
28-Day Compressive Strength (psi)	4795	5398
7-Day Flexural Strength (psi)	540	581
28-Day Flexural Strength (psi)	658	716

Table 4 – Average Compressive and Flexural Strengths

Control Mix	**Avg. w/c Ratio**
05/23/01	.455
05/29/01	.452
Water Reducer Mix	**Avg. w/c Ratio**
05/23/01	.467
05/29/01	.446

Table 5 – Average Water/Cement Ratios

APPENDIX A

(Freeze/Thaw Results)

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Control	*573*	*0.0*	*8.0*	*0.412*	1.50	**1.50**	**1RJ5B013**	27.9
Interval 1							**1RJ5B014**	38.8
							1RJ5B015	48.0
FREEZE/THAW RESULTS NOT INCLUDED DUE TO LOW AIR CONTENT							**1RJ5B016**	36.9
							1RJ5B017	54.9
							1RJ5B018	56.6
							Average	**44**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Control	580	0.0	8.0	0.457	1.50	6.90	1RJ5B079	71.6
Interval 2							1RJ5B080	87.7
							1RJ5B081	79.5
							1RJ5B082	88.5
							1RJ5B083	84.8
							1RJ5B084	86.1
							Average	**83.0**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Control	*573*	*0.0*	*8.0*	*0.412*	1.75	6.70	1RJ5B101	79.9
Interval 3							1RJ5B102	72.2
							1RJ5B103	82.2
							1RJ5B104	85.0
							1RJ5B105	74.0
							1RJ5B106	83.2
							1RJ5B107	86.0
							1RJ5B108	80.1
							Average	**80.3**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Control	570	0.0	9.0	0.453	2.25	6.90	1RJ5B173	89.2
Interval 4							1RJ5B174	88.6
							1RJ5B175	74.6
							1RJ5B176	84.9
							1RJ5B177	74.5
							1RJ5B178	83.1
							1RJ5B179	88.5
							1RJ5B180	86.9
							Average	**83.8**

AVERAGE F/T DURABILITY FOR CONTROL MIXES **82.4**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Water Reducer Interval 1	546	20.0	2.5	0.428	1.00	8.00	1RJ5B035	75.9
							1RJ5B036	78.3
							1RJ5B037	85.2
							1RJ5B038	84.7
							1RJ5B039	85.9
							1RJ5B040	79.3
							Average	**81.6**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Water Reducer Interval 2	544	19.8	2.4	0.368	1.50	5.80	1RJ5B057	80.1
							1RJ5B058	85.5
							1RJ5B059	85.9
							1RJ5B060	80.8
							1RJ5B061	80.3
							1RJ5B062	83.5
							Average	**82.7**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Water Reducer Interval 3	544	20.1	3	0.455	0.75	7.00	1RJ5B125	76.7
							1RJ5B126	81.8
				NOT INCLUDED			1RJ5B127	65.3
							1RJ5B128	51.2
							1RJ5B129	83
							1RJ5B130	79.3
							1RJ5B131	80.8
							1RJ5B132	79.7
							Average	**80.2**

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	F/T Durability (%)
Water Reducer Interval 4	548	19.8	3	0.445	1.25	6.10	1RJ5B149	77.7
							1RJ5B150	87.3
							1RJ5B151	82.5
							1RJ5B152	86.6
							1RJ5B153	80.7
							1RJ5B154	83.9
							1RJ5B155	82.2
							1RJ5B156	88.4
							Average	**84.1**

AVERAGE F/T DURABILITY FOR WR MIXES 82.1

APPENDIX B

(Air Void Analysis Worksheets)

CONTROL 1

Summary of speciman 1R021.CHO on 12/04/2001
ASTM C-457 Procedure A

Length = 106.193
Percent Air = 2.032
Average Air Void = 0.01226
Void/Paste Ratio = 0.039
Percent Paste = 51.51
Paste/Void Ratio = 25.35
Standard Dev of Air Void Sizes = 0.0295
Voids Per Inch = 1.66
Spacing Factor = 0.02911
Specific Surface = 326.28

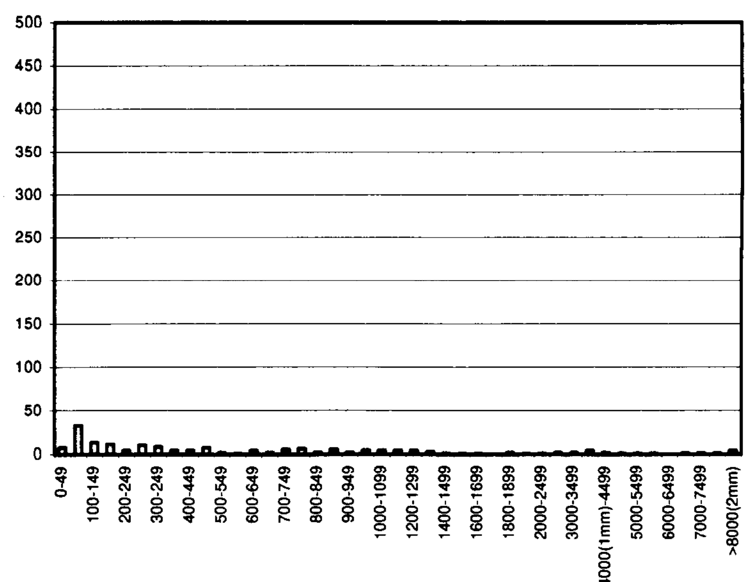
Specification Range: 0.004 - 0.008
Specification Range: 600 - 1100

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	7	3.98	50	99 =	33	22.73	100	149 =	13	30.11
150	199 =	11	36.36	200	249 =	4	38.64	250	299 =	10	44.32
300	349 =	8	48.86	350	399 =	4	51.14	400	449 =	4	53.41
450	499 =	7	57.39	500	549 =	2	58.52	550	599 =	1	59.09
600	649 =	4	61.36	650	699 =	2	62.5	700	749 =	5	65.34
750	799 =	6	68.75	800	849 =	2	69.89	850	899 =	5	72.73
900	949 =	2	73.86	950	999 =	4	76.14	1000	1049 =	2	77.27
1050	1099 =	2	78.41	1100	1149 =	2	79.55	1150	1199 =	2	80.68
1200	1249 =	2	81.82	1250	1299 =	2	82.95	1300	1349 =	1	83.52
1350	1399 =	2	84.66	1400	149 =	1	85.23	1450	1499 =	0	85.23
1500	1549 =	1	85.8	1550	1599 =	0	85.8	1600	1649 =	1	86.36
1650	1699 =	0	86.36	1700	1749 =	0	86.36	1750	1499 =	0	86.36
1800	1849 =	1	86.93	1850	1899 =	1	87.5	1900	1949 =	0	87.5
1950	1999 =	1	88.07	2000	2499 =	1	88.64	2500	2999 =	2	89.77
3000	3499 =	2	90.91	3500	3999 =	4	93.18	4000	4499 =	2	94.32
4500	4999 =	1	94.89	5000	5499 =	1	95.45	5500	5999 =	1	96.02
6000	6499 =	0	96.02	6500	6999 =	1	96.59	7000	7499 =	1	97.16
7500	7999 =	1	97.73	>=	8000 =	4	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	2.032	3.944
<600	0.193	0.375
Tot Pct	59.09	
Tot No	104	
600-4000 (1 mm)	0.758	1.471
Tot Pct	34.09	
Tot No	60	
4000 (1 mm) - 8000 (2mm)	0.431	0.837
Tot Pct	4.55	
Tot No	8	
> 8000 (2mm)	0.65	1.261
Tot Pct	0	
Tot No	4	



CONTROL 2

Summary of speciman 1R087.CHO on 12/04/2001
ASTM C-457 Procedure A

Length = 94.28951
Void/Paste Ratio = 0.079
Standard Dev of Air Void Sizes = 0.00873
Spacing Factor = 0.00644
Specification Range: 0.004 - 0.008

Percent Air = 3.726
Percent Paste = 46.95

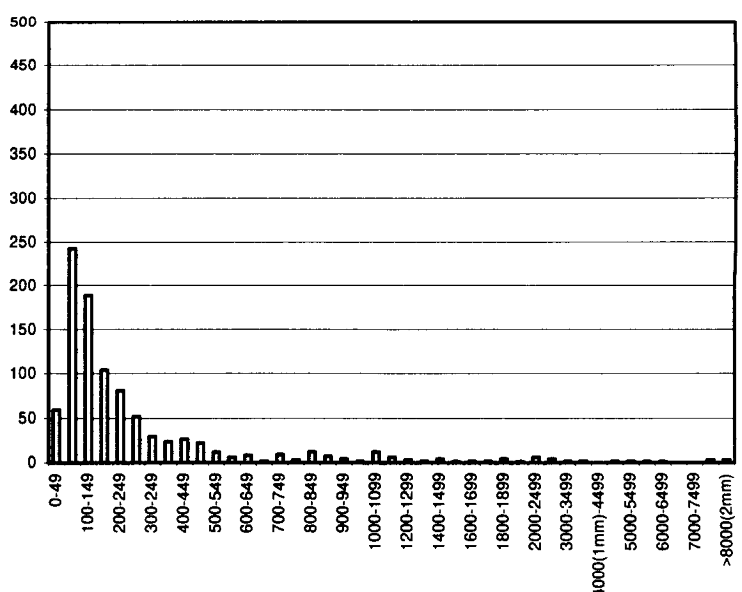
Average Air Void = 0.00367
Paste/Void Ratio = 12.6
Voids Per Inch = 10.16
Specific Surface = 1090.66
Specification Range: 600 - 1100

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	59	6.16	50	99 =	243	31.52	100	149 =	189	51.25
150	199 =	104	62.11	200	249 =	81	70.56	250	299 =	52	75.99
300	349 =	30	79.12	350	399 =	24	81.63	400	449 =	27	84.45
450	499 =	22	86.74	500	549 =	12	88	550	599 =	6	88.62
600	649 =	8	89.46	650	699 =	2	89.67	700	749 =	9	90.61
750	799 =	3	90.92	800	849 =	12	92.17	850	899 =	7	92.9
900	949 =	4	93.32	950	999 =	1	93.42	1000	1049 =	7	94.15
1050	1099 =	5	94.68	1100	1149 =	4	95.09	1150	1199 =	2	95.3
1200	1249 =	0	95.3	1250	1299 =	3	95.62	1300	1349 =	1	95.72
1350	1399 =	1	95.82	1400	149 =	2	96.03	1450	1499 =	2	96.24
1500	1549 =	1	96.35	1550	1599 =	0	96.35	1600	1649 =	1	96.45
1650	1699 =	1	96.56	1700	1749 =	0	96.56	1750	1499 =	2	96.76
1800	1849 =	3	97.08	1850	1899 =	1	97.18	1900	1949 =	0	97.18
1950	1999 =	1	97.29	2000	2499 =	6	97.91	2500	2999 =	4	98.33
3000	3499 =	2	98.54	3500	3999 =	2	98.75	4000	4499 =	0	98.75
4500	4999 =	2	98.96	5000	5499 =	2	99.16	5500	5999 =	1	99.27
6000	6499 =	1	99.37	6500	6999 =	0	99.37	7000	7499 =	0	99.37
7500	7999 =	3	99.69	>=	8000 =	3	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	3.726	7.936
<600	1.53	3.259
Tot Pct	88.62	
Tot No	849	
600-4000 (1 mm)	1.32	2.811
Tot Pct	10.13	
Tot No	97	
4000 (1 mm) - 8000 (2mm)	0.579	1.233
Tot Pct	0.94	
Tot No	9	
> 8000 (2mm)	0.298	0.634
Tot Pct	0	
Tot No	3	



CONTROL 3

Summary of speciman 1R111.CHO on 12/04/2001
ASTM C-457 Procedure A

Length = 93.72668   Percent Air = 4.876   Average Air Void = 0.00346

Void/Paste Ratio = 0.095   Percent Paste = 51.29   Paste/Void Ratio = 10.52

Standard Dev of Air Void Sizes = 0.00741   Voids Per Inch = 14.07

Spacing Factor = 0.00562   Specific Surface = 1154.51

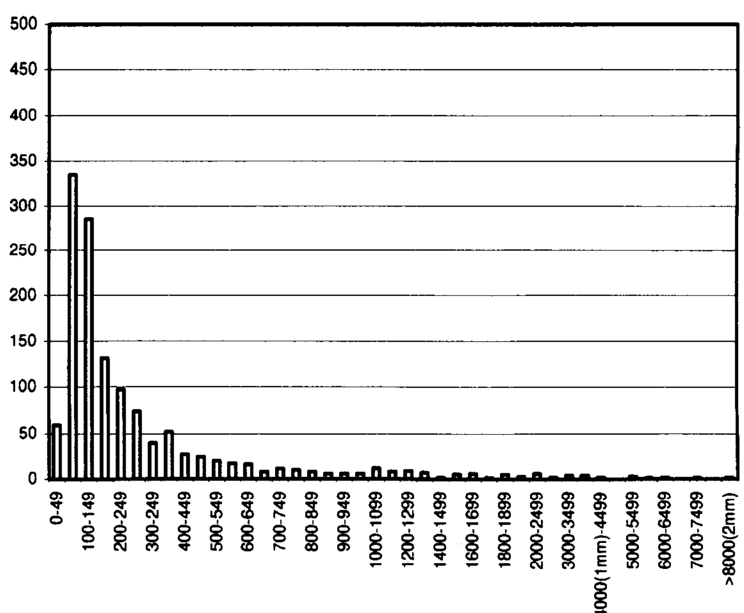
Specification Range: 0.004 - 0.008   **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	59	4.47	50	99 =	335	29.87	100	149 =	286	51.55
150	199 =	132	61.56	200	249 =	97	68.92	250	299 =	73	74.45
300	349 =	40	77.48	350	399 =	52	81.43	400	449 =	27	83.47
450	499 =	24	85.29	500	549 =	20	86.81	550	599 =	17	88.1
600	649 =	16	89.31	650	699 =	8	89.92	700	749 =	11	90.75
750	799 =	10	91.51	800	849 =	8	92.12	850	899 =	6	92.57
900	949 =	6	93.03	950	999 =	6	93.48	1000	1049 =	6	93.93
1050	1099 =	6	94.39	1100	1149 =	2	94.54	1150	1199 =	6	95
1200	1249 =	4	95.3	1250	1299 =	5	95.68	1300	1349 =	4	95.98
1350	1399 =	3	96.21	1400	149 =	0	96.21	1450	1499 =	2	96.36
1500	1549 =	3	96.59	1550	1599 =	2	96.74	1600	1649 =	4	97.04
1650	1699 =	2	97.19	1700	1749 =	1	97.27	1750	1499 =	1	97.35
1800	1849 =	1	97.42	1850	1899 =	4	97.73	1900	1949 =	1	97.8
1950	1999 =	2	97.95	2000	2499 =	6	98.41	2500	2999 =	2	98.56
3000	3499 =	4	98.86	3500	3999 =	4	99.17	4000	4499 =	2	99.32
4500	4999 =	0	99.32	5000	5499 =	3	99.55	5500	5999 =	1	99.62
6000	6499 =	2	99.77	6500	6999 =	0	99.77	7000	7499 =	1	99.85
7500	7999 =	0	99.85	>=	8000 =	2	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.876	9.507
<600	2.174	4.238
Tot Pct	88.1	
Tot No	1162	
600-4000 (1 mm)	1.933	3.769
Tot Pct	11.07	
Tot No	146	
4000 (1 mm) - 8000 (2mm)	0.53	1.034
Tot Pct	0.68	
Tot No	9	
> 8000 (2mm)	0.239	0.466
Tot Pct	0	
Tot No	2	



CONTROL 4

Summary of speciman 1R183.CHO on 12/04/2001
ASTM C-457 Procedure A

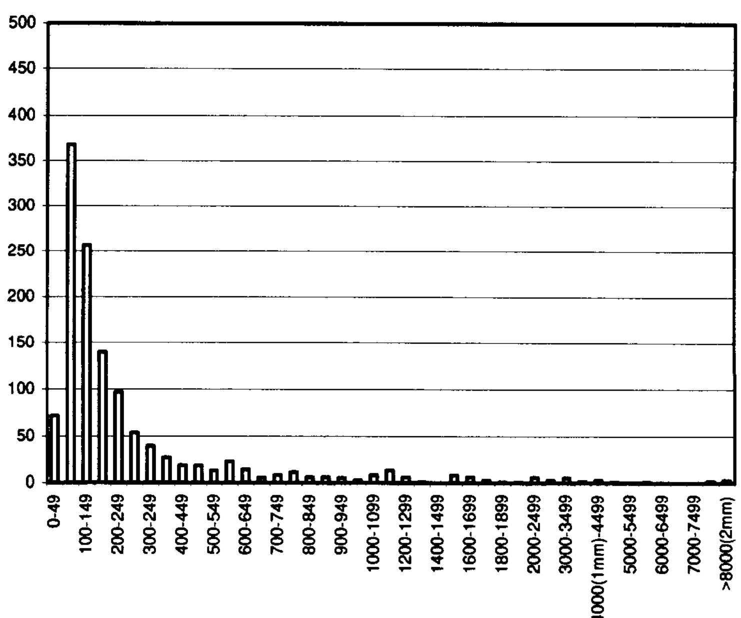
Length = 93.95881
Percent Air = 4.332
Average Air Void = 0.00324
Void/Paste Ratio = 0.088
Percent Paste = 49.41
Paste/Void Ratio = 11.41
Standard Dev of Air Void Sizes = 0.00795
Voids Per Inch = 13.39
Spacing Factor = 0.00544
Specific Surface = 1236.38
Specification Range: 0.004 - 0.008
Specification Range: 600 - 1100

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	72	5.72	50	99 =	368	34.98	100	149 =	257	55.41
150	199 =	140	66.53	200	249 =	97	74.24	250	299 =	54	78.54
300	349 =	39	81.64	350	399 =	27	83.78	400	449 =	19	85.29
450	499 =	18	86.72	500	549 =	13	87.76	550	599 =	23	89.59
600	649 =	14	90.7	650	699 =	5	91.1	700	749 =	8	91.73
750	799 =	11	92.61	800	849 =	6	93.08	850	899 =	6	93.56
900	949 =	5	93.96	950	999 =	3	94.2	1000	1049 =	4	94.52
1050	1099 =	4	94.83	1100	1149 =	5	95.23	1150	1199 =	8	95.87
1200	1249 =	5	96.26	1250	1299 =	1	96.34	1300	1349 =	0	96.34
1350	1399 =	1	96.42	1400	149 =	0	96.42	1450	1499 =	0	96.42
1500	1549 =	2	96.58	1550	1599 =	6	97.06	1600	1649 =	6	97.54
1650	1699 =	0	97.54	1700	1749 =	2	97.69	1750	1499 =	1	97.77
1800	1849 =	1	97.85	1850	1899 =	0	97.85	1900	1949 =	0	97.85
1950	1999 =	1	97.93	2000	2499 =	6	98.41	2500	2999 =	3	98.65
3000	3499 =	5	99.05	3500	3999 =	2	99.21	4000	4499 =	3	99.44
4500	4999 =	1	99.52	5000	5499 =	0	99.52	5500	5999 =	1	99.6
6000	6499 =	0	99.6	6500	6999 =	0	99.6	7000	7499 =	0	99.6
7500	7999 =	2	99.76	>=	8000 =	3	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.332	8.766
<600	1.929	3.904
Tot Pct	89.59	
Tot No	1127	
600-4000 (1 mm)	1.634	3.307
Tot Pct	9.62	
Tot No	121	
4000 (1 mm) - 8000 (2mm)	0.409	0.828
Tot Pct	0.56	
Tot No	7	
> 8000 (2mm)	0.36	0.728
Tot Pct	0	
Tot No	3	



WR INTERVAL 1

Summary of speciman 1R043.CHO on 12/05/2001
ASTM C-457 Procedure A

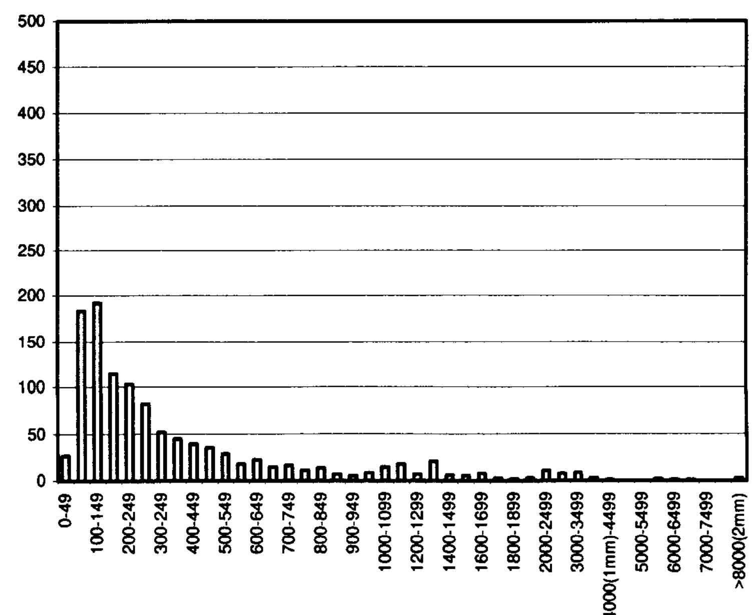
Length = 94.48513
Percent Air = 5.975
Average Air Void = 0.0049
Void/Paste Ratio = 0.131
Percent Paste = 45.47
Paste/Void Ratio = 7.61
Standard Dev of Air Void Sizes = 0.01293
Voids Per Inch = 12.19
Spacing Factor = 0.00687
Specific Surface = 816.21
Specification Range: 0.004 - 0.008
Specification Range: 600 - 1100

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	27	2.34	50	99 =	183	18.23	100	149 =	192	34.9
150	199 =	115	44.88	200	249 =	103	53.82	250	299 =	83	61.02
300	349 =	52	65.54	350	399 =	45	69.44	400	449 =	40	72.92
450	499 =	36	76.04	500	549 =	29	78.56	550	599 =	18	80.12
600	649 =	23	82.12	650	699 =	15	83.42	700	749 =	17	84.9
750	799 =	12	85.94	800	849 =	14	87.15	850	899 =	7	87.76
900	949 =	5	88.19	950	999 =	9	88.98	1000	1049 =	7	89.58
1050	1099 =	8	90.28	1100	1149 =	7	90.89	1150	1199 =	11	91.84
1200	1249 =	2	92.01	1250	1299 =	5	92.45	1300	1349 =	9	93.23
1350	1399 =	12	94.27	1400	149 =	1	94.36	1450	1499 =	5	94.79
1500	1549 =	2	94.97	1550	1599 =	3	95.23	1600	1649 =	4	95.57
1650	1699 =	4	95.92	1700	1749 =	1	96.01	1750	1499 =	2	96.18
1800	1849 =	1	96.27	1850	1899 =	1	96.35	1900	1949 =	2	96.53
1950	1999 =	1	96.61	2000	2499 =	11	97.57	2500	2999 =	8	98.26
3000	3499 =	9	99.05	3500	3999 =	3	99.31	4000	4499 =	1	99.39
4500	4999 =	0	99.39	5000	5499 =	0	99.39	5500	5999 =	2	99.57
6000	6499 =	1	99.65	6500	6999 =	1	99.74	7000	7499 =	0	99.74
7500	7999 =	0	99.74	>=	8000 =	3	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	5.975	13.141
<600	2.085	4.586
Tot Pct	80.12	
Tot No	923	
600-4000 (1 mm)	2.996	6.59
Tot Pct	19.18	
Tot No	221	
4000 (1 mm) - 8000 (2mm)	0.299	0.657
Tot Pct	0.43	
Tot No	5	
> 8000 (2mm)	0.595	1.308
Tot Pct	0	
Tot No	3	



WR INTERVAL 2

Summary of speciman 1R065.CHO on 12/05/2001
ASTM C-457 Procedure A

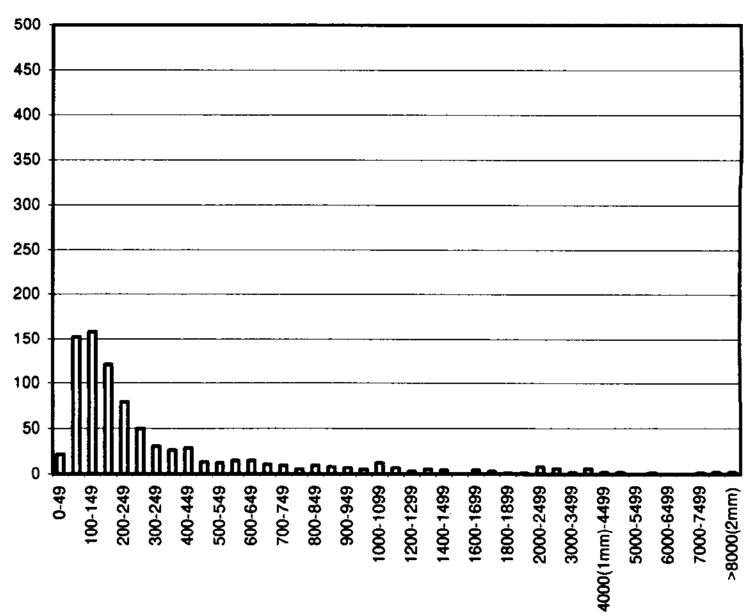
Length = 94.63906 Percent Air = 4.025 Average Air Void = 0.00445
Void/Paste Ratio = 0.084 Percent Paste = 48.13 Paste/Void Ratio = 11.96
Standard Dev of Air Void Sizes = 0.0095 Voids Per Inch = 9.04
Spacing Factor = 0.00764 Specific Surface = 898.78
Specification Range: 0.004 - 0.008 **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	22	2.57	50	99 =	152	20.33	100	149 =	158	38.79
150	199 =	121	52.92	200	249 =	80	62.27	250	299 =	50	68.11
300	349 =	31	71.73	350	399 =	27	74.88	400	449 =	29	78.27
450	499 =	14	79.91	500	549 =	13	81.43	550	599 =	15	83.18
600	649 =	15	84.93	650	699 =	11	86.21	700	749 =	10	87.38
750	799 =	5	87.97	800	849 =	10	89.14	850	899 =	8	90.07
900	949 =	7	90.89	950	999 =	5	91.47	1000	1049 =	6	92.17
1050	1099 =	7	92.99	1100	1149 =	4	93.46	1150	1199 =	3	93.81
1200	1249 =	2	94.04	1250	1299 =	1	94.16	1300	1349 =	1	94.28
1350	1399 =	4	94.74	1400	149 =	1	94.86	1450	1499 =	3	95.21
1500	1549 =	0	95.21	1550	1599 =	0	95.21	1600	1649 =	2	95.44
1650	1699 =	2	95.68	1700	1749 =	0	95.68	1750	1499 =	3	96.03
1800	1849 =	1	96.14	1850	1899 =	0	96.14	1900	1949 =	1	96.26
1950	1999 =	0	96.26	2000	2499 =	8	97.2	2500	2999 =	6	97.9
3000	3499 =	2	98.13	3500	3999 =	6	98.83	4000	4499 =	2	99.07
4500	4999 =	2	99.3	5000	5499 =	0	99.3	5500	5999 =	1	99.42
6000	6499 =	0	99.42	6500	6999 =	0	99.42	7000	7499 =	1	99.53
7500	7999 =	2	99.77	>=	8000 =	2	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.025	8.364
<600	1.463	3.04
Tot Pct	83.18	
Tot No	712	
600-4000 (1 mm)	1.82	3.782
Tot Pct	15.65	
Tot No	134	
4000 (1 mm) - 8000 (2mm)	0.49	1.019
Tot Pct	0.93	
Tot No	8	
> 8000 (2mm)	0.251	0.522
Tot Pct	0	
Tot No	2	



WR INTERVAL 3

Summary of speciman 1R135.CHO on 12/05/2001
ASTM C-457 Procedure A

Length = 94.0634 | Percent Air = 3.901 | Average Air Void = 0.00477
Void/Paste Ratio = 0.08 | Percent Paste = 48.64 | Paste/Void Ratio = 12.47
Standard Dev of Air Void Sizes = 0.00887 | Voids Per Inch = 8.18
Spacing Factor = 0.00834 | Specific Surface = 838.17

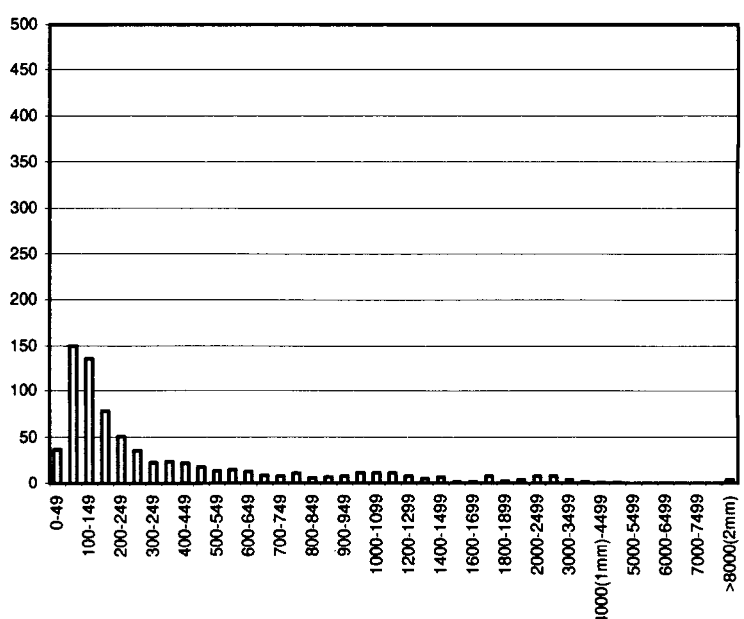
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	37	4.81	50	99 =	150	24.32	100	149 =	135	41.87
150	199 =	79	52.15	200	249 =	51	58.78	250	299 =	36	63.46
300	349 =	23	66.45	350	399 =	24	69.57	400	449 =	22	72.43
450	499 =	18	74.77	500	549 =	14	76.59	550	599 =	15	78.54
600	649 =	13	80.23	650	699 =	9	81.4	700	749 =	8	82.44
750	799 =	11	83.88	800	849 =	6	84.66	850	899 =	7	85.57
900	949 =	8	86.61	950	999 =	12	88.17	1000	1049 =	9	89.34
1050	1099 =	3	89.73	1100	1149 =	7	90.64	1150	1199 =	5	91.29
1200	1249 =	2	91.55	1250	1299 =	6	92.33	1300	1349 =	3	92.72
1350	1399 =	2	92.98	1400	149 =	6	93.76	1450	1499 =	1	93.89
1500	1549 =	2	94.15	1550	1599 =	0	94.15	1600	1649 =	2	94.41
1650	1699 =	0	94.41	1700	1749 =	1	94.54	1750	1499 =	7	95.45
1800	1849 =	2	95.71	1850	1899 =	1	95.84	1900	1949 =	2	96.1
1950	1999 =	2	96.36	2000	2499 =	8	97.4	2500	2999 =	8	98.44
3000	3499 =	4	98.96	3500	3999 =	2	99.22	4000	4499 =	1	99.35
4500	4999 =	1	99.48	5000	5499 =	0	99.48	5500	5999 =	0	99.48
6000	6499 =	0	99.48	6500	6999 =	0	99.48	7000	7499 =	0	99.48
7500	7999 =	0	99.48	>=	8000 =	4	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	3.901	8.021
<600	1.213	2.494
Tot Pct	78.54	
Tot No	604	
600-4000 (1 mm)	2.193	4.508
Tot Pct	20.68	
Tot No	159	
4000 (1 mm) - 8000 (2mm)	0.095	0.196
Tot Pct	0.26	
Tot No	2	
> 8000 (2mm)	0.4	0.823
Tot Pct	0	
Tot No	4	



WR INTERVAL 4

Summary of speciman 1R159.CHO on 12/05/2001
ASTM C-457 Procedure A

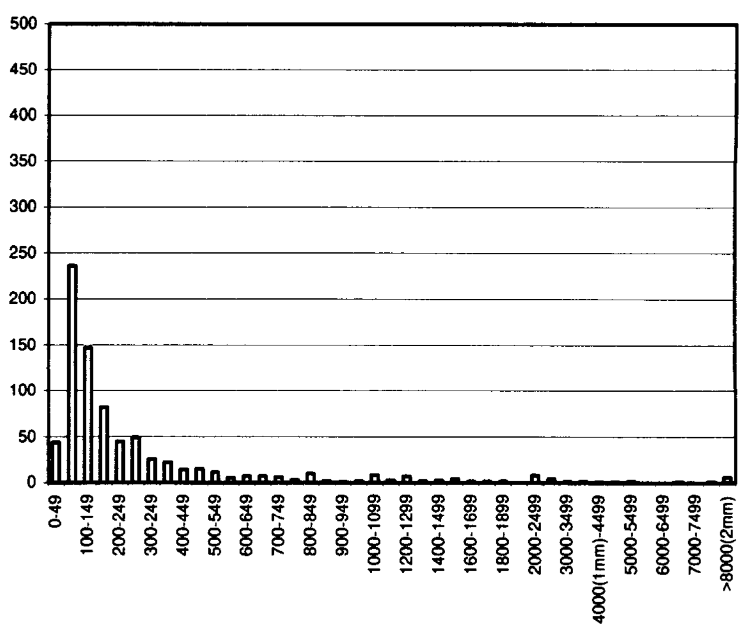
Length = 94.15021 Percent Air = 3.617 Average Air Void = 0.00429
Void/Paste Ratio = 0.071 Percent Paste = 50.85 Paste/Void Ratio = 14.06
Standard Dev of Air Void Sizes = 0.01333 Voids Per Inch = 8.43
Spacing Factor = 0.0079 Specific Surface = 932.72
Specification Range: 0.004 - 0.008 **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	44	5.54	50	99 =	236	35.26	100	149 =	147	53.78
150	199 =	82	64.11	200	249 =	45	69.77	250	299 =	49	75.94
300	349 =	25	79.09	350	399 =	22	81.86	400	449 =	14	83.63
450	499 =	15	85.52	500	549 =	11	86.9	550	599 =	5	87.53
600	649 =	7	88.41	650	699 =	7	89.29	700	749 =	6	90.05
750	799 =	3	90.43	800	849 =	10	91.69	850	899 =	2	91.94
900	949 =	1	92.07	950	999 =	2	92.32	1000	1049 =	3	92.7
1050	1099 =	5	93.32	1100	1149 =	1	93.45	1150	1199 =	2	93.7
1200	1249 =	5	94.33	1250	1299 =	2	94.58	1300	1349 =	0	94.58
1350	1399 =	2	94.84	1400	149 =	2	95.09	1450	1499 =	1	95.21
1500	1549 =	1	95.34	1550	1599 =	3	95.72	1600	1649 =	2	95.97
1650	1699 =	0	95.97	1700	1749 =	1	96.1	1750	1499 =	1	96.22
1800	1849 =	2	96.47	1850	1899 =	0	96.47	1900	1949 =	0	96.47
1950	1999 =	0	96.47	2000	2499 =	8	97.48	2500	2999 =	4	97.98
3000	3499 =	2	98.24	3500	3999 =	2	98.49	4000	4499 =	1	98.61
4500	4999 =	1	98.74	5000	5499 =	2	98.99	5500	5999 =	0	98.99
6000	6499 =	0	98.99	6500	6999 =	1	99.12	7000	7499 =	0	99.12
7500	7999 =	1	99.24	>=	8000 =	6	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	3.617	7.113
<600	1.2	2.36
Tot Pct	87.53	
Tot No	695	
600-4000 (1 mm)	1.238	2.435
Tot Pct	10.96	
Tot No	87	
4000 (1 mm) - 8000 (2mm)	0.358	0.704
Tot Pct	0.76	
Tot No	6	
> 8000 (2mm)	0.821	1.614
Tot Pct	0	
Tot No	6	



APPENDIX C

(Chloride Permeability Testing)

CONTROL MIXES

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Control Mix	573	0.0	8.0	0.455	1.50	1.50	1R089	4503	4451	2955
Interval 1				RESULTS NOT INCLUDED			1R090			3552

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Control Mix	573	0.0	8.0	0.455	1.50	6.90	1R085	4557	4215	3949
Interval 2							1R086	4834	5029	3886
							AVG.	4696	4622	3918

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Control Mix	573	0.0	9.0	0.457	1.75	6.70	1R109	4500	6267	4327
Interval 3							1R110	3841	4862	3511
							AVG.	4171	5565	3919

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Control Mix	573	0.0	9.0	0.457	2.25	6.90	1R181	6080	5892	4766
Interval 4							1R182	5835	6320	3822
							AVG.	5958	6106	4294

High	4,000	High w/c ratio (=>0.6)
Moderate	2,000-4,000	Mod. w/c ratio (0.4-0.5)
Low	1,000-2,000	Low w/c ratio
Very Low	100-1,000	Latex Mod. Concrete
Negligible	100	Polymer Impregnated

	28-DAY TOP LIFT 1	28-DAY MIDDLE LIFT 2	56-DAY BOTTOM LIFT 3
TOTAL AVG.	4941	5431	4044

WATER REDUCER MIXES

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Water Reducer Interval 1	546	20.0	2.5	0.467	1.00	8.00	1R041	3516	3431	4430
							1R042	3838	3708	4310
							AVG.	3677	3570	4370

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Water Reducer Interval 2	546	20.0	2.5	0.467	1.50	5.80	1R063	3734	3776	2596
							1R064	3428	3485	3305
							AVG.	3581	3631	2951

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Water Reducer Interval 3	546	20.0	3	0.448	0.75	7.00	1R133	3574	3621	3047
							1R134	3304	2989	2779
							AVG.	3439	3305	2913

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	Specimen ID	Chloride Permeability 28-Day Lift 1	28-Day Lift 2	56-Day Lift 3
Water Reducer Interval 4	546	20.0	3	0.448	1.25	6.10	1R157	3502	4208	3148
							1R158	2952	3253	2692
							AVG.	3227	3731	2920

High	4,000	High w/c ratio (=>0.6)
Moderate	2,000-4,000	Mod. w/c ratio (0.4-0.5)
Low	1,000-2,000	Low w/c ratio
Very Low	100-1,000	Latex Mod. Concrete
Negligible	100	Polymer Impregnated

	28-DAY TOP LIFT 1	28-DAY MIDDLE LIFT 2	56-DAY BOTTOM LIFT 3
TOTAL AVG.	**3481**	**3559**	**3288**

APPENDIX D

(Compressive and Flexural Strength Testing)

CONTROL MIX

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Control Mix	573	0.0	8.0	0.412	1.50	1.50	4761	6381	614	872
Interval 1							4885	6250	668	784
							4809	6535	633	771
					Average		4818	6389	638	809
					Standard Deviation		63	143	27	55

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Control Mix	580	0.0	8.0	0.457	1.50	6.90	4064	5547	652	695
Interval 2							3992	5270	462	678
							3554	5157	537	661
					Average		3870	5325	550	678
					Standard Deviation		276	201	96	17

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Control Mix	573	0.0	8.0	0.412	1.75	6.70	3574	4403	533	737
Interval 3							3376	4441	557	626
							3368	4870	561	631
					Average		3439	4571	550	665
					Standard Deviation		117	259	15	63

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Control Mix	570	0.0	9.0	0.453	2.25	6.90	3594	4599	528	654
Interval 4							3455	4404	508	599
							3507	4464	524	643
					Average		3519	4489	520	632
					Standard Deviation		70	100	11	29

WR MIXES

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Water	*546*	*20.0*	*2.5*	*0.428*	1.00	8.00	2736	4130	521	652
Reducer							3206	4049	503	615
Interval 1							3288	4519	518	710
					Average		3077	4233	514	659
					Standard Deviation		298	251	10	48

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Water	544	19.8	2.4	0.368	1.50	5.80	4173	6310	607	712
Reducer							4405	6010	614	775
Interval 2							4155	5832	629	701
					Average		4244	6051	617	729
					Standard Deviation		139	242	11	40

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Water	544	20.1	3	0.455	0.75	7.00	4153	5619	584	730
Reducer							4426	5546	548	698
Interval 3							4090	5574	559	758
					Average		4223	5580	564	729
					Standard Deviation		179	37	18	30

Mix Name	Cement & FlyAsh (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/yd^3)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength
Water	548	19.8	3	0.445	1.25	6.10	4708	5738	651	738
Reducer							4422	5611	639	752
Interval 4							4486	5839	600	756
					Average		4539	5729	630	749
					Standard Deviation		150	114	27	9